CHAPTER 6 TRANSFORMATION OF THE AIR TRAFFIC CONTROL SYSTEM

"Flying has torn apart the relationship of space and time: it uses our old clock but with new yardsticks."

~ Charles A. Lindbergh

6 Transformation of the Air Traffic Control System

The National Airspace System is the largest and most complex aviation system in the world. The FAA's modernization of this interdependent system is being implemented as an evolutionary process that will sustain current NAS operations while new technologies are introduced, proven, and then deployed. The transformation of the FAA's air traffic control system is a key part of this modernization. The FAA is undertaking major changes in the infrastructure of the air traffic control system and at the same time is moving from a centralized command-and-control system to one of air traffic management in which controllers and pilots have a collaborative working relationship.

A more efficient use of the national airspace is the chief object of the transformation of the air traffic control system. Airport capacity can be increased with the construction of new airports and runways at existing airports, but airspace capacity can be increased through the better use of existing airspace. The current airspace structure was created by the FAA to ensure the safe operation of a variety of aircraft, but the constraints of that structure have the effect of restricting the use of that airspace. Easing those restrictions, while ensuring safety, is the primary goal of air traffic management.

The previous two chapters focused on changes in how the FAA manages airspace, by redesigning the existing airspace structure and developing new operational procedures. This chapter shows how the replacement of existing equipment and the introduction of new technologies enables the implementation of those new structures and procedures.

6.1 Free Flight and The National Airspace System

Free Flight, the organizing principle of the transformation of the air traffic control system, is a response to increasing demand on that system. Despite decreases in traffic in the last two years, FAA forecasts call for a gradual return to pre-September 11th levels and a large increase over the next decade. The existing airspace architecture and management will not be able to handle this increase in traffic without an increase in delays. Free Flight will give pilots the flexibility to select their own routes, consistent with safety, bringing substantial benefits, including fuel and time savings, fewer delays and the more efficient use of airspace. Free Flight calls for limiting pilot flexibility only in certain situations, such as to ensure separation at high-traffic airports and in congested airspace, or to prevent unauthorized entry into special use airspace. The FAA designed its Free Flight program to deliver technologies that would benefit passengers, pilots and controllers immediately. The new software includes the following:

- ➢ The User Request Evaluation Tool (URET), which gives controllers a 20-minute projection of flight paths.
- ➢ The Traffic Management Advisor (TMA), which funnels aircraft from high altitudes toward busy airports.
- ➢ The Surface Movement Advisor (SMA), which provides controllers and airlines with precise touchdown times, enabling better management of gates.
- ➢ Collaborative Decision Making (CDM), which enables the airlines and the FAA to maneuver aircraft and schedules to reduce congestion and the impact of bad weather.

The Free Flight Phase 1 program has successfully completed the installation of the above technologies at all of its initial sites and has been expanded to others. The new technologies are bringing real and measurable improvements as follows:

- ➢ With the User Request Evaluation Tool, Memphis and Indianapolis centers are providing increased direct routings, resulting in savings in aircraft direct operating costs of $1.5 million per month. In addition, the Indianapolis center has eliminated more than 22 static restrictions, saving users nearly $1 million per year in fuel costs.
- ➢ The Traffic Management Advisor provides metered traffic flows to the Dallas/Ft. Worth, Denver, and Minneapolis airports, resulting in more fuel-efficient traffic flows and increases of three-to-five percent in peak capacity at these airports.
- ➢ Northwest Airlines has estimated that the Surface Movement Advisor has helped it avoid three-to-five diversions a week, especially during inclement weather.

The second part of the program, Free Flight Phase 2, builds on the foundation of Free Flight Phase 1 and features the expansion of Phase 1 elements, including the national deployment of URET and TMA. FFP2 will also provide incremental enhancements to URET and TMA during the period 2003-2005.

6.2 Major Developments in Navigation Systems

The FAA and the aviation community are on the cusp of a revolution in air navigation. The key to the coming changes is the Global Positioning System (GPS) constellation of satellites that provide greater accuracy and reliability than current ground-based navigation systems. GPS-based navigation systems will overcome the limitations of these ground-based systems. Among the most promising of the satellite-based navigation systems are the Wide Area Augmentation System, the Local Area Augmentation System, and Automatic Dependent Surveillance-Broadcast.

6.2.1 Wide Area Augmentation Systems

The Wide Area Augmentation System (WAAS) is a supplement to the basic GPS signal. It provides a signal-in-space, broadcast from Geostationary Earth Orbit (GEO) satellites that improve ranging accuracy, availability, continuity and data integrity. WAAS will support en route navigation, non-precision approaches, and approaches with lateral navigation/vertical navigation operations. WAAS is expected to provide major benefits to the airlines, the traveling public, and the FAA, which include:

- ➢ Increased air traffic control efficiencies and NAS capacity through an airspace system that is restructured to accommodate direct routings between airports, as well as reduced separation standards.
- ➢ Reduced fuel cost to airlines and reduced travel time to the public through the use of more economical air routes.
- ➢ Reduced FAA operating costs through the potential decommissioning of existing ground-based navigation equipment.
- ➢ Simplified GPS augmentation infrastructure through the introduction of wide area and interoperability that provides satellite navigation services at a reduced cost.

In January 2003, the FAA accepted WAAS from its primary contractor, eight months ahead of schedule. Then, the FAA commissioned WAAS on July 10, 2003. Commissioning is the process the

FAA uses to define the point where a new system is deemed safe and ready for incorporation into the NAS. The commissioning deems WAAS reliable for pilots who depend on its use in safety-critical situations. The WAAS commissioning represents a key milestone for the aviation community.

The WAAS milestone is the first step toward opening pilot access to more than 500 published satellite runway procedures at more than 200 airports. Pending certification of avionics with vertical navigation capabilities and approval of individual approach procedures, pilots will be able to navigate as low as 350 feet above the runway under instrument flight rules using satellite navigation to provide stable vertical guidance. Later this year, a new procedure will be published for the full capability of WAAS, resulting in approaches down to 250 feet above the runway. WAAS will allow precision instrument approaches at thousands of runways at airports and airstrips that have little or no ground-based capability. WAAS will also provide improved en route capabilities because pilots can fly more direct routes without depending on ground-based navigation aids.

WAAS is also a critical component of Required Navigation Performance (RNP). WAAS can provide the most stringent RNP for area navigation to all classes of users. As air traffic management becomes more global, WAAS can be applied to the civil aviation infrastructure worldwide, enabling global safety improvements. Also, with more stringent RNP standards, inefficiencies in airspace utilization will be reduced.

The FAA continues to work toward final operational capability for WAAS to include a full complement of WAAS satellites, which will ensure that each receiver sees at least two GEO satellites at all times throughout the continental U.S. and most of Alaska. WAAS will be incrementally improved to expand the availability of non-precision approaches and area navigation, increase signal redundancy, reduce operational restrictions, and support precision approach operations. Future phases of WAAS are expected to provide precision approach capability, and potentially enable the decommissioning of some existing ground-based navigation equipment throughout the United States. The FAA is also working with Canada and Mexico to expand the WAAS coverage area to support North American implementation of WAAS.

6.2.2 Local Area Augmentation Systems

In 2003, the FAA awarded a contract for the Local Area Augmentation System (LAAS), which provides for the software and initial hardware design of the Category I LAAS. Phases II and III will cover the final development and full production of the Category I system.

The Local Area Augmentation System is, like WAAS, a supplement of the global positioning system. LAAS will provide highly accurate navigation signals to suitably equipped aircraft. LAAS will provide Category II/III precision approach and landing capability and accurate navigation signals for aircraft and vehicles on the airport surface. LAAS should provide the following efficiencies and cost savings:

- Increased number of instrument approaches, extending all-weather service to more cities and reduce the traffic complexity resulting from back-course approaches and circle-to-land operations.
- Lower landing minima, improving on-time performance by reducing the frequency of flight disruptions such as missed approaches, diversions, delays, and cancellations.
- Increased number of approaches with vertical guidance and improved safety by reducing the risk of controlled-flight-into-terrain accidents.

- ➢ Increased navigation accuracy and flexibility and improved traffic efficiency by facilitating more effective NAS configurations and optimized fuel/time navigation solutions.

- ➢ Reduced infrastructure costs as many surface navigational aids are decommissioned in favor of space-based systems.

LAAS is intended to complement WAAS. The two navigation systems will function together to supply users of the NAS with seamless satellite-based navigation for all phases of flight. LAAS will be used to meet Category I precision approach requirements at those locations where WAAS is unable to meet them. LAAS will also be used to meet the more stringent Category II/III requirements at selected locations throughout the U.S. LAAS augments GPS by focusing navigation service in the airport area (a 20-to-30 mile radius). LAAS broadcasts its correction message via a VHF radio data link from a ground-based transmitter.

The contract for the first phase of the LAAS provides for the software and hardware design of the Category I LAAS. Category I precision landing provides a level of service in poor weather conditions down to a ceiling of 200 feet and visibility of one-half mile. The first system is scheduled to be operational by late 2006. Phases II and III will cover the development and full production of the Category I system. If the Phase II option of the contract is exercised, the operational Low Rate Initial Production LAAS will be installed in Juneau, Phoenix, Chicago, Memphis, Houston, and Seattle, each with a single LAAS providing approach guidance for multiple runway ends. Air carriers will use the six systems to assess operational benefits while in daily service.

The development of the Category I LAAS is a stepping-stone to Category II/III systems. The FAA is continuing research and development activities on Category II/III LAAS to define high-level system performance requirements and to mitigate critical technical risk areas. The full economic benefit for the FAA will come when the FAA is able to eliminate some of the ground-based navigation aids. For the foreseeable future, however, a significant number of navaids will be retained to provide a robust and redundant navigational capacity.

6.2.3 Automatic Dependent Surveillance – Broadcast

The Automatic Dependent Surveillance-Broadcast (ADS-B) system broadcasts aviation information via digital data link between a source and multiple destinations. Aircraft equipped with ADS-B avionics broadcast their position, airspeed, altitude, and planned course changes. Receivers on the ground, as well as ADS-B avionics aboard other aircraft, receive this information. The information can then be processed and displayed to the controller or the pilot, providing a picture of area traffic.

The FAA is testing ADS-B and related data link technologies in a government and industry effort called Safe Flight 21. The Safe Flight 21 initiative focuses on developing suitable avionics, pilot procedures for air-to-air surveillance of other aircraft, and a compatible ground-based automatic dependent surveillance system for air traffic control facilities. Safe Flight 21 demonstration projects are underway at two sites:

- ➢ The FAA is conducting the Alaska Capstone Program to evaluate ADS-B and data link technologies in western and southeastern Alaska. Commercial aircraft are conducting passenger, mail, and freight flights using Capstone avionics provided by the FAA.

- ➢ The FAA is conducting the Ohio River Valley Project to evaluate ADS-B and data link technologies in commercial cargo operations in terminal areas in the Midwest.

6.2.3.1 Alaska Capstone Program

The Capstone Program was developed by the FAA in response to a National Transportation Safety Board (NTSB) safety study, Aviation Safety in Alaska, to address Alaska's high accident rate for small aircraft, which is five times the national average. A recent FAA-sponsored study estimated that 38 percent of commercial operator accidents in Alaska could be avoided if information on position relative to terrain and real-time weather information were available to pilots in the cockpit. The principal objective of the Capstone Program is to improve pilots' situational awareness of the flight environment and to thereby avoid mid-air collisions and controlled flight into terrain. The FAA plans to initially demonstrate the benefits of these technologies in Alaska, but it will eventually extend those technologies to the entire NAS. Although the initial benefits of the Capstone technologies will be to improve safety, the use of GPS-based navigation that is being developed in Alaska will help expand capacity in the rest of the NAS.

In Phase I of the Capstone Program, the FAA equipped 120 commercial aircraft in a non-radar environment in the Yukon-Kuskokwim Delta region of southwest Alaska with Capstone avionics. The avionics suite includes a cockpit multifunction display, a GPS navigation/communications unit, a Universal Access Transceiver data link unit, and a GPS-based terrain database of Alaska. These avionics enable each participating aircraft to broadcast its identification, position, and altitude, climb rate, and direction and to receive similar signals from other aircraft. The FAA has also installed a network of data link ground stations that will transmit radar targets of non-participating aircraft to the Capstone aircraft. In addition, the ground stations will transmit flight information services, including weather reports and forecasts, maps, status of special use airspace, pilot reports, and notices to airmen. The initial improvements of Capstone have been directed towards pilots conducting Visual Flight Rule operations. In the future, the FAA plans to certify systems and equipment and develop enhanced operational procedures for Instrument Flight Rule operations. When this is accomplished, ADS-B will be able to be used for air traffic control functions just as radar is now used.

In Phase II of the Capstone Program, the FAA will equip approximately 200 aircraft, including 50 helicopters, in southeast Alaska, with Capstone Phase II equipment. Capstone Phase II will also provide for implementation of an RNAV infrastructure in southeast Alaska using advanced navigation, communication, and surveillance technologies.

Early in 2003, in a demonstration of Capstone Phase II, LAB Flying Services conducted the first commercial flight of a Capstone-equipped aircraft in southeastern Alaska. Under the authority of a Special Federal Aviation Regulation, they operated a flight from Juneau International Airport based solely on GPS navigation. LAB's Cessna Seneca has been outfitted with the latest version of the Capstone suite of computer equipment and software to receive satellite communications.

The newest suite of Capstone avionics included the first commercial use of an advanced Electronic Flight Information System. Its primary flight display features real-time 3-D terrain modeling, airspeed, groundspeed, altitude, altitude above ground, and many other types of flight information. A second in-cockpit display features an aeronautical map that includes weather data and air traffic information. The map displays the flight plan, along with terrain and traffic near the aircraft's current altitude. Incorporated into the program is a WAAS capability, which uses satellites and ground-based receivers for precise navigation. The new equipment will permit aircraft to fly new lower minimum en route altitudes, opening up thousands of miles of airspace over some 1,500 nautical miles of existing routes.

6.2.3.2 Ohio River Valley Project

The FAA's Ohio River Valley Project is testing ADS-B avionics on commercial cargo aircraft in the Ohio River Valley. These tests are taking place in terminal areas with significant cargo operations, including Memphis, Tennessee; Wilmington, Ohio; Louisville, Kentucky; Scott Air Force Base, Illinois; and, Nashville, Tennessee. The Ohio River Valley Project is co-sponsored by the Cargo Airline Association (CAA) and the FAA. The CAA has purchased, equipped, and is maintaining the avionics for the test aircraft. The CAA members are conducting revenue flights with these aircraft to evaluate the systems' performance in normal operations. This initiative is another step in the evolutionary process of bringing emerging technologies into the NAS. The Ohio River Valley project evaluates the following issues:

- Addresses pilot and controller human factors issues.
- Develops and assesses new operational procedures and the associated training.
- Streamlines certification processes and procedures.
- Develops a cost-effective avionics and NAS infrastructure.
- Defines a realistic NAS transition path that is supported by the user community.

The FAA has purchased, installed, and is maintaining ground systems at the five sites. A ground broadcast server has been installed at the Wilmington site that receives data from the other sites and depicts ADS-B targets fused with radar targets. As the project proceeds, fused ADS-B and radar target data will be made available to suitably-equipped aircraft to enable the pilots to see both targets on a cockpit display, along with selected broadcast information such as weather maps, special use airspace status, and wind shear alerts.

As part of the Ohio River Valley Project, the FAA has established or modified operational concepts and procedures, including departure spacing, runway and final approach occupancy awareness, and airport surface operational awareness. In addition, the FAA installed a special Common Automated Radar Terminal System at the Louisville TRACON for evaluation by controllers in their work with airborne ADS-B applications and has installed a multilateration ADS-B surface surveillance system at Memphis in order to conduct an evaluation of surface management. That evaluation was completed in 2001.

As the Ohio River Valley Project continues, the FAA and industry will share the funding of avionics and ground systems to support on ongoing industry initiatives. These include resolving ADS-B technology issues; continuing extensive data collection activities during operational evaluations; and, developing an integrated cockpit display of terrain, traffic, and weather conditions. Throughout the project, the FAA will ensure that controllers and both commercial and general aviation pilots are included in the evaluation of operational enhancements and data link.

6.3 Replacement and Modernization of Air Traffic Control Equipment

Much of the equipment of the FAA's air traffic control system is aging and needs to be replaced. As the FAA replaces this older equipment, it will take advantage of the tremendous advances in computer technology to significantly increase the equipment's capabilities. The FAA will also ensure that new equipment will be in an open architecture that can be easily expanded and updated in the future. The key near-term replacements programs are: the Standard Terminal Automation Replacement System, an upgrade of the terminal air traffic control system; the Advanced

Technologies and Oceanic Procedures, the replacement of the oceanic air traffic control system; and the En Route Automation Modernization, the replacement of the underlying software for the radar processing computers.

6.3.1 Standard Terminal Automation Replacement System

The Standard Terminal Automation Replacement System (STARS) is a joint FAA and Department of Defense program to replace Automated Radar Terminal Systems (ARTS) and other capacity-constrained systems at FAA and Department of Defense terminal radar approach control facilities and associated towers. STARS will work in conjunction with digital radar systems to allow air traffic controllers to track aircraft within the terminal area. The new equipment and software are based on a digital platform and provide higher-resolution screens with color capabilities and higher system reliability. STARS can also be expanded to meet increased traffic demand and to accommodate new automation functions.

The STARS program has been significantly revised since its first definition in 1996. It was originally designed to use off-the-shelf technology, with little specialized software development. However, in consultation with air traffic controllers and the airways facilities maintenance technicians, the FAA concluded that it needed to develop a more customized system and to implement it incrementally. In March 2002, the FAA reduced the number of facilities that will be receiving STARS from 188 to 74 and changed the date to complete installation at all of those facilities from 2005 to 2008.

The first full STARS deployment took place at the Philadelphia TRACON on November 17, 2002. The FAA used the STARS system at Philadelphia to control live traffic, which is considered initial operating capability, but retained the earlier air traffic control system as a backup until the new system was formally commissioned. The STARS system at Philadelphia has eased capacity limitations in the busy terminal airspace. Philadelphia was running out of capacity to track the hundreds of flights either heading for or leaving Philadelphia International Airport or flying overhead en route to different East Coast destinations. STARS is able to track about 750 aircraft simultaneously.

After six months of testing, the FAA commissioned the Philadelphia STARS on June 9, 2003. The commissioning meant the backup ARTS could be turned off. The commissioning signals the start of the nationwide deployment schedule and opens the way for rapid commissioning at other sites. The emphasis is on getting STARS first to the TRACONs with the oldest equipment at the more than 50 sites nationwide still using the ARTS IIIA system.

STARS is also operational, but not yet commissioned, at Portland, Oregon, Syracuse, New York, and El Paso, Texas. In addition, 11 other sites have partial installations, with displays only, that will be upgraded by late 2004. The FAA plans to deploy only seven all-new systems in 2003, down from the 18 previously scheduled, as the result of budgetary constraints. The final number of sites is undetermined, since only the first 74 have been approved for the initial phase through 2005.

6.3.2 En Route Automation Modernization Program

In 1999, the computers for the air traffic control system at the 20 domestic centers were finally withdrawn from service. The Host and Oceanic Computer System Replacement (HOCSR) Program replaced the interim computers that had supported the air traffic control system from the mid-1980's. The new system has extremely high reliability, significantly improved maintainability, and more complete backup than the equipment it replaced.

The new HOCSR computers will be able to be used until at least 2008, but the primary En Route Automation System (the Host Computer System), which receives, processes, coordinates, distributes, and tracks information on aircraft movements throughout the nation's airspace, is based upon the original software. Those programs were written in a computer language that is not widely used now and therefore are difficult to upgrade to meet new requirements.

The FAA is developing the En Route Automation Modernization (ERAM) Program to replace the existing hardware and software in the Host Computer System and its backup, the direct access radar channel (DARC) and associated interfaces, communications, and support infrastructures. The Host processes flight radar data, provides communications support, and generates display data to air traffic controllers. It also connects to air traffic control towers, TRACONs, flight service stations, adjacent flight information regions, and external organizations. The new ERAM automation architecture will provide existing functionality and new capabilities to support the NAS architecture evolution, operational requirements, and information security requirements. ERAM will modernize the en route environment and infrastructure to provide a system that is modular, expandable, and supportable. The ERAM contract was awarded in March 2003. The system will be installed in all centers by 2008. ERAM will also provide:

- Safety Alerts using the backup system.
- Flexible routing around congestion, weather, and restrictions.
- Increased number and type of surveillance sources with improved surface coverage.
- Capabilities for incorporating environments.

6.3.3 Advanced Technologies and Oceanic Procedures System

The Advanced Technologies and Oceanic Procedures (ATOP) System will replace the oceanic systems at Anchorage, New York, and Oakland centers, which handle air traffic in international airspace over the Pacific and Atlantic oceans. ATOP will collect, manage, and display oceanic air traffic data, including electronic flight strip data on the computer displays used by air traffic controllers and integrate capabilities such as flight data processing, and radar data processing. The FAA expects that ATOP will provide huge benefits to the airlines, which will be able to take advantage of improved communications and reduced separation and more flexible routing on oceanic routes.

The FAA took delivery of the Oakland Build I system in July 2003 and will proceed to conduct tests at the FAA Technical Center to ensure that the system can be used operationally. Site acceptance and operational tests for Build I will be carried out at Oakland, followed by controller and technician training and familiarization tests. Initial operating capability will take place in spring 2004 and initial daily use will follow shortly thereafter. Independent operational tests and an evaluation phase will lead to an in-service decision, probably in late 2004. Build I initial operating capability at the New York oceanic center will follow thereafter.

In the second phase of the ATOP program, Build II will be delivered to the Anchorage oceanic center by September 2004. Retrofits to the other oceanic centers will take place a few months later. Anchorage will be the first of the oceanic centers to get Build II and will not get the Build I version. Build II will include integrated radar processing and an improved conflict resolution probe, both of which are needed for 30-nautical mile separation standards and also incorporate automatic dependent surveillance-broadcast. FAA has committed to introduce these reduced separation standards in the South Pacific by mid-2005.